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Preliminary observations on the food preference of certain Collembola (Insecta)

BY

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Much has been said about the food and feeding habits of Collembola. MACNAMARA (1924), SPENCER & STRACENER (1929), INGRAM (1931), WOMERSLEY (1932), EATON (1943), BROWN (1954), MURPHY & DONCASTER (1957) observed Collembola feeding on a variety of food in the natural habitat. AGRELL (1940), SCHALLER (1950), POOLE (1959), and SINGH (1964 a, b) examined the gut content and suggested that collembola feed on fungi, higher plant tissues, humus, faeces, bacteria, nematodes and testate amoebae. NEF (1957) gave quantitative data on food and food preferences of soil inhabiting animals and has also briefly mentioned Collembola. However none of these workers go into the question of food preference. The present paper deals with a comparative and experimental study of the food preference of three species of Collembola viz. *Tomocerus longicornis* (Müller), *Onychiurus armatus* (Tullberg) and *Neanura muscorum* (Templeton). Incidentally the study was also designed to determine whether these insects were actually feeding on the various types of micro-organisms found in their gut contents or whether these micro-organisms were ingested incidentally.

MATERIAL AND METHODS

Natural inclusions in the form of fungi, yeast and bacteria were recovered from the gut content of *T. longicornis, O. armatus, N. muscorum* and *F. mirabilis*, and identified and a pure stock culture of these was raised. The following fungi including one colony of yeast were isolated viz. (1) *Penicillium*, (2) *Aspergillus*, (3) *Mucor*, (4) *Streptomyces*, (5) Yeast, (6) *Thysanophora*, (7) Sub culture '5', (8) Sub-culture '7', (9) Sub-culture '9', (10) Sub-culture '10'. Out of ten different

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types of fungi isolated from the gut of these insects the first six were identified to genera, while the rest could not be identified and have been referred to by their culture numbers. In addition to the above, a culture of a common soil fungus *(Rhizopus)* was also maintained and offered to the insects. A brief description of the unidentified fungi is given in the following footnote.

Three different types of bacteria, namely *Pseudomonas, Anthracoides* and *Staphylococcus* were recovered and identified from the gut of the four species. These were isolated and stocks of pure colonies maintained in the laboratory. Depending on their size, the feeding experiments were carried out in small circular flat-bottomed glass crystallising dishes 10 cm diameter × 6 1/2 cm deep for *T. longicornis*; and 7 1/2 cm diameter × 5 cm deep for *O. armatus* and *N. nuscorum*. The bottom of the dish was covered with moist filter paper to provide adequate humidity and a suitable substratum on which the insects could move about freely. Liquid food was within easy reach of the insects. A circle, the radius of which was half an inch less than that of the experimental vessel was drawn on the filter paper or blotting paper and the alternative food staffs were arranged on his line at equal distances. Care was taken not to place two similar kinds of food stuff side by side. Insects were placed in the centre of the experimental vessels. The treatment of the insects before experimental feeding was the same for all the experiments. Collembola were allowed to feed on their natural diet, that is *T. longicornis* and *O. armatus* were fed on decaying wood containing micro-organisms, for twelve hours and then they were starved for 48 hours before each experiment. For the experiments only visibly active and healthy insects were selected. In each experiment fifteen individuals were placed in the centre of the experimental dishes. Each experiment was carried out with different sets of insects. Observations were made, using a binocular dissecting microscope and a variable intensity spot lamp. At the time of the first observation the number and the positions of the insects were graphically noted and thus subsequent movements, if any, were followed as far as possible. Results noted show the number of insects feeding on each colony as observed at intervals of 1 1/2 to 7 1/2 hours after the commencement of the experiment. Experiments were designed on the assumption that once the animals have commenced feeding they dnot change place until they are satisfied or the food supply is exhausted (unpublished observation).

OBSERVATION AND DISCUSSION

Experiments (see Appx-A) showed that *T. longicornis* and *O. armatus* fed actively on nearly all the fungi which were recovered from the gut, *T. longicornis* however appeared to show slight preference for brown fungi of the family Dematiacae and *O. armatus* showed preference for *Penicillium* and *Aspergillus*. They fed on humus, decaying wood and dead leaf litter if

Footnote: A brief description of the unidentified cultures:

(a) Sub-culture No. 5. — The hyphae in this colony were very thin, colourless, septate and branched. The conidiophores were hyaline and branched. The conidia were hyaline, one celled and numerous.

(b) Sub-culture No. 7. — The hyphae were brown in colour, septate and branched. The conidiophores were branched and bore light to dark brown, single or two celled conidia. The conidia were fewer in number.

(c) Sub-culture No. 9. — The hyphae were hyaline and light green in colour, branched and septate. The conidiophores were branched, bearing very long chains of light green conidia.

(d) Sub-culture No. 10. — The hyphae were brown in colour, hyaline, septate, branched with thick dark coloured septa. Sporangiophores were septate, branched, bearing a few, one to four celled conidia.

Appendix 'A'

Experiments to investigate whether collembola will feed on the type fungi recovered from their gut contents and whether preference for any of them is shown

Experiment Nos.	*Thysanophora*	*Aspergillus*	*Penicillium*	Yeast	*Streptomyces*	Sub-culture No. 5	Sub-culture No. 7	Sub-culture No. 9	Sub-culture No. 10	Total Number feeding	Total number abstained from feeding
Tomocerus longicornis.											
1	2	3	2	1	×	2	1	1	3	15	×
2	1	×	×	×	×	1	2	1	4	9	6
3	1	1	1	×	×	3	2	2	5	15	×
4	2	1	3	2	×	1	3	1	×	13	2
5	×	×	×	1	×	×	4	1	×	6	9
6	1	1	2	1	×	1	2	×	2	10	5
7	×	1	1	2	×	3	3	1	4	15	×
8	1	1	1	1	×	3	2	1	4	14	1
9	1	×	1	2	×	1	4	1	5	15	×
10	×	1	1	1	×	1	3	×	4	11	4
Total	9	9	12	11	×	16	26	9	31	123	27
Onychiurus armatus.											
1	3	3	3	2	×	×	1	1	2	15	×
2	2	4	3	2	×	×	2	×	2	15	×
3	2	4	3	×	×	1	2	2	×	14	1
4	3	1	1	3	×	3	×	×	×	11	4
5	4	2	2	1	×	1	1	×	1	12	3
6	2	3	3	1	×	×	1	1	2	13	2
7	×	1	1	2	×	3	3	1	4	15	×
8	1	2	5	2	×	2	×	1	2	15	×
9	×	3	3	2	×	×	2	1	3	14	1
10	×	2	3	2	×	×	1	2	1	11	4
Total	17	26	27	17	×	11	13	10	18	135	15
Neanura muscorum.											
1	2	1	2	1	×	×	×	×	×	6	9
2	1	1	2	2	×	×	×	×	1	7	8
3	1	3	2	×	×	×	×	×	×	6	9
4	×	×	3	2	×	×	×	×	1	6	9
5	2	2	3	2	×	×	×	×	×	9	6
6	6	2	2	2	×	×	×	×	×	12	3
7	1	2	2	1	×	×	1	×	×	7	8
8	1	3	2	1	×	×	×	×	1	8	7
9	×	1	3	2	×	×	×	1	×	7	8
10	1	2	3	2	×	×	×	×	×	8	7
Total	15	17	24	15	×	×	1	1	3	76	74

Appendix 'B'

Experiments to investigate whether *T. longicornis*, *O. armatus* and *N. muscorum* will feed on bacteria recovered from their gut contents and also to test their preference between fungi and bacteria

Experiment Nos.	*Penicillium*	*Aspergillus*	Yeast	Sub-culture No. 7	Sub-culture No. 10	*Pseudomonas* (− I)	*Anthracoides* (+ I)	*Staphylococcus* (+ C)	Total Nos. feeding	Total Nos. not feeding
Tomocerus longicornis.										
1	2	3	×	3	3	×	1	×	12	3
2	2	2	1	4	5	1	×	×	15	×
3	1	2	1	3	4	×	×	×	11	4
4	1	3	×	2	5	×	×	×	11	4
5	1	1	×	2	4	×	1	2	11	4
Total	7	11	2	14	21	1	2	2	60	11
Onychiurus armatus.										
1	3	3	2	1	1	×	1	×	11	4
2	2	3	1	×	1	×	1	1	9	6
3	2	4	×	3	2	1	1	×	13	2
4	3	4	×	2	3	1	×	×	13	2
5	2	1	1	3	2	1	×	×	10	5
Total	12	15	4	9	9	3	3	1	56	19
Neanura muscorum.										
1	2	3	2	×	×	1	×	2	10	5
2	5	4	3	×	×	×	×	1	13	2
3	4	3	2	×	×	×	1	2	12	3
4	5	4	1	×	×	1	1	×	12	3
5	1	3	×	×	1	1	×	×	6	9
Total	17	17	8	×	1	3	2	5	53	22

micro-organisms were present in the food but not if it was sterilised (see Appx-C). This agrees with the view of Jacot (1939) and Schaller (1950).

Both species accept bacteria as food but when a fungus is offered as an alternative, it is preferred (see Appx-B. *T. longicornis* and *O. armatus* and *N. muscorum* refused to feed on the parasitic fungus *(Streptomyces)* which of course is not commonly found in their gut contents.

Examination of the gut contents also showed that in *N. muscorum*, unlike that found in *T. longicornis* and *O. armatus*, the fungal material eaten was in the form of fine particles. These would float on the surface water film of the filter paper on which the food was offered. Among the fungi

N. muscorum preferred *Penicillium* and *Aspergillus*. A suspension of fungal spores was preferred to bacteria; but the preference for fungi shifted to the humus when the latter was offered as an alternative. *T. longicornis*, *O. armatus* and *N. muscorum* did not feed on mineral soil or distilled water even when soaked in cotton wool or sterile wood. Presence of mineral particles in the gut suggests that they have entered the gut accidentally. These insects are found mostly in the soil covered with decaying plant or other organic matter. This agrees with the finding of Haarløv (1960). It was observed that *T. longicornis* and *O. armatus* which possessed a molar plate on the mandible preferred to feed on the hyphae and spores of Dematiacae, while *N. muscorum*, a fluid feeding form without a molar plate on the mandible, preferred spores of *Aspergillus* and *Penicillium* to their hyphae. All these three insects preferred yeast to sugar and starch, but decaying wood was preferred to yeast, sugar and starch if offered as on alternative food.

Appendix 'C'

Experiments to investigate if *T. longicornis*, *O. armatus* and *N. muscorum* showed any preference between fungi, decaying wood and humus

Experiment Nos.	*Penicillium*	*Aspergillus*	Sub-culture No. 7	Sub-culture No. 10	Sterile humus	Sterile wood	Decaying wood	Humus	Total Nos. feeding	Total Nos. not feeding
Tomocerus longicornis.										
1	×	1	3	4	×	×	2	4	14	1
2	1	×	2	6	×	×	2	2	13	2
3	×	×	3	4	×	×	3	3	13	2
4	1	×	3	4	×	×	1	4	13	2
5	×	1	2	5	×	×	3	3	14	1
Total	2	2	13	23	×	×	11	16	67	8
Onychiurus armatus.										
1	1	2	1	×	×	×	6	4	14	1
2	1	1	1	3	×	×	4	3	13	2
3	1	×	1	2	×	×	3	4	11	4
4	×	1	3	2	×	×	5	2	13	2
5	×	1	1	3	×	×	4	4	13	2
Total	3	4	7	10	×	×	22	17	64	11
Neanura muscorum.										
1	×	1	×	×	×	×	7	2	10	5
2	×	×	×	×	×	×	9	×	9	6
3	×	1	×	×	×	×	11	×	12	3
4	1	×	×	×	×	×	8	3	12	3
5	1	1	×	×	×	×	10	2	14	1
Total	2	3	×	×	×	×	45	7	57	18

The collembola, *T. longicornis*, *O. armatus*, *N. muscorum* feed on a variety of foods but fungal colonies and humus are preferred. *O. armatus feeds* on fungi with smaller spores and finer hyphae while *T. longicornis* feeds mainly on larger spores and hyphae. *N. muscorum* preferred fine particles

APPENDIX 'D'

Experiments to determine whether *T. longicornis*, *O. armatus* and *N. muscorum* will feed on starch in various forms

Experiment Nos.	Starch dry	Starch in suspension	Starch suspension soaked in cotton wood	Starch suspension soaked in sterilised wood	Distilled water soaked in sterilised wood	Total Nos. feeding	Total Nos. not feeding
Tomocerus longicornis.							
1	×	1	1	1	×	3	12
2	×	×	2	2	×	4	11
3	×	×	1	×	×	1	14
4	×	×	1	3	×	4	11
5	×	1	2	1	×	4	11
Total	×	2	7	7	×	16	59
Onychiurus armatus.							
1	×	×	1	1	×	2	13
2	×	1	2	×	×	3	12
3	×	×	1	1	×	2	13
4	×	×	2	3	×	5	10
5	×	1	2	1	×	4	11
Total	×	2	8	6	×	16	59
Neanura muscorum.							
1	×	2	3	2	×	7	8
2	×	2	2	1	×	5	10
3	×	1	2	3	×	6	9
4	×	3	4	1	×	8	7
5	×	1	2	3	×	6	9
Total	×	9	13	10	×	32	43

or minute spores in suspension. The texture of the substrate in which the food is suspended, appears to affect the preference. All four species refuse to feed on food devoid of organic matter and micro-organism (see Appx-C and D).

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REFERENCES

AGRELL (I), 1940. — « Die Arthropoden fauna von Madeira nach den Ergebnissen der Reise von Prof. Dr. O. Lunbdlad Juli-August 1935. XVIII. Collembola ». *Ark. Zool.*, **31**: 1-7.

BROWN (W. L.), 1954. — « Collembola feeding upon Nematodes ». *Ecology*. **35**: 421.

EATON (T. H.), 1943. — « Biology of Mull forming millipede, *Apheloria coriacea* (Koch ». *Amer. Midl. Nat.*, **29**: 713-723.

HAARLØV (N.), 1960. — « Microarthropods from Danish soils. Ecology, Phenology ». *Oikos, Suppl.* **3**: 1-176.

INGRAM (J. W.), 1931. — « Soil animals attacking sugar cane ». *Jour. econ. Ent.* **24**: 866-869.

JACOT (A. P.), 1939. — « Reduction of Spruce and Fir litter by minute animals. » *J. For.*, **37**: 858-860.

MACNAMARA (C.), 1924. — « The food of collembola ». *Canad. Ent.* **56**: 99-105.

MURPHY (P. W.) & DONCASTER (C. C.), 1957. — « A culture method for soil meiofauna and its application to the study of nematode predators ». *Nematologica*, **2**: 202-214.

NEF (L.), 1957. — « État actuel des connaissances sur le rôle des animaux dans la décomposition des litières de forêts. » *Agriculture*, **5**: 245-316.

POOLE (T. B.), 1959. — « Studies on the food of Collembola in a Douglas fir plantation. » *Proc. zool. Soc. Lond.*, **132**: 71-82.

SCHALLER (F.), 1950. — « Biologische Beobachtungen an humus bildenden Bodentieren, insbesondere an Collembolan. » *Zool. Jahrb. Abt. Syst. Oekol.*, **78**: 506-525.

SINGH (S. B.), 1964 a. — Periodicity in the feeding habit of *Tomocerus longicornis* (Müller), Collembola. *Indian J. Ent.*, **24**: 123-124.

SINGH (S. B.), 1964 b. — A preliminary observation on the food and feeding habits of some Collembola. *Entomologist*, **97**: 153-154.

SPENCER (H.) & STRACENER (C. L.), 1929. — « Soil animals injurious to sugar cane. » *Ann. ent. Soc. Amer.*, **22**: 641-649.

WOMERSLEY (H.), 1932. — « The collembola - symphypleona. A preliminary account. » *Pamph. Comm. sci. industr. Res. Aust.*, **34**: 1-47.